Northern Rivers Soil Health Card

Macadamia

A tool for farmers to assess the biological and physical properties of soil on their farms.

For more than two decades, the Northern Rivers Soil Health Card has provided an essential resource to farmers, agriculture-horticulture professionals, and educators.

Updated 2025

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1. Introduction

'A basic soil audit is the first and sometimes the only monitoring tool used to assess changes in the soil. Unfortunately, the standard soil test done to determine nutrient levels (P, K, Ca, Mg, etc.) provides no information on soil biology and physical properties. Yet most of the farmer-recognized criteria for healthy soils include, or are created by, soil organisms and soil physical properties. A better appreciation of these biological and physical soil properties, and how they affect soil management and productivity, has resulted in the adoption of new soil health assessment techniques.'

National (USA) Sustainable Agriculture Information Service http://attra.ncat.org

In 2002 the Northern Rivers Soil Health Card was developed as an extension activity of the Good Soil Project, a joint undertaking of Tuckombil Landcare Inc and NSW Agriculture in partnership with the Natural Heritage Trust.

The card was developed through a series of workshops held at NSW North Coast TAFE Wollongbar. Primary producers representing a range of industries and one urban gardener attended the workshops. The process was facilitated by staff of Wollongbar TAFE and NSW Agriculture. The aim was to develop a practical tool for farmers in the Northern Rivers Region to monitor the health of their soils.

In 2007 macadamia growers on the Alstonville Plateau and surrounding area adapted the soil health card for use on local macadamia farms. The card was adapted in workshops held at NSW North Coast TAFE Wollongbar and facilitated by staff of NSW North Coast TAFE Wollongbar and NSW DPI. This activity was sponsored and funded by the Northern Rivers Catchment Management Authority, the Natural Heritage Trust, SoilCare Inc, Richmond Landcare Inc, NSW Department of Primary Industries and TAFE Wollongbar.

Participants are acknowledged individually at the end of this document.

The Northern Rivers Macadamia Soil Health Card lists 10 tests and provides space for you to rate your own soils after carrying out the tests. By testing regularly and keeping the cards, you can build up a record of your soil health, and understand the effect of management practices on soil health.

Regular testing will show improvements in response to more sustainable management such as additions of organic matter or introducing living ground covers in orchards, and allow early detection of developing soil problems. Test results can also be used as the basis for discussion about management changes with other landholders and with agricultural advisers.

Please note: This card is not intended to replace any soil testing that you may already carry out. It is another tool to help you understand your soils and their productivity. Maintaining soil health in the short term will undoubtedly increase the sustainability of farming into the future.

2. HOW TO USE YOUR SOIL HEALTH CARD

1. READ ALL THE INFORMATION FIRST.

This will help you go out into the paddock ready for action.

2. WHEN TO TEST

Best results will be obtained in autumn, two to ten days after good rain. To allow comparison of results from year to year, sample at the same time of year and under similar conditions. Avoid taking samples from overly wet soils or during drought, at times of extreme high or low temperatures and within a few weeks of fertiliser or lime applications.

3. WHERE YOU WILL TEST

We recommend you start with two sites, one to represent your 'best' soil and the other your 'worst' area. This will give you a good overview of how the tests relate to soil conditions on your land. You can then select other areas to get a broader understanding of the health of your soil. Remember to record the location of each sample site for future testing.

4. DECIDE HOW MANY CARDS YOU NEED

At each site you select, you may want to use more than one card if:

- there is more than one soil type within the selected area
- conditions under row crops are quite different in the inter-row (e.g. light, groundcover, traffic)
- for comparison perform one test in an undisturbed area outside but adjacent to the orchard

5. PREPARE YOUR EQUIPMENT

Make the 3 simple pieces of test equipment, using the instructions on Sheet 4, and gather together all the other items listed on the equipment list on Sheet 3.

6. CARRY OUT THE TESTS

Each card lists the 10 tests and has space on the back for you to draw a sketch map of the site and show the test sites. Once you are familiar with the tests it will take you around 20 minutes to carry out one set of tests. Each card has room for you to record up to five sets of tests at the site. We recommend that you do the five sets of tests as they will provide a broad picture of the soil conditions at the selected site.

7. REVIEW YOUR TEST PROCEDURE

As you become more familiar with the test procedures and your soils, check whether the sites you have selected are the best sites for the information you need. Also review the way you do your tests to ensure consistency. Make notes as you go to remind yourself next time.

8. REVIEW YOUR RESULTS AND FOLLOW UP ON LOW SCORES

Line up your test sheets for areas you wish to compare and look for similarities and differences among your scores for the 10 tests. Can you explain the differences? If you have neighbours also undertaking tests, get together with them and compare notes. Where you have low scores in the results, refer to sheet that lists possible causes; obtain and read the literature linked to those tests in order to find out how you might improve your soil health. Discuss your results with an agricultural adviser or NSW DPI extension officer.

9. MAKE SURE THE TEST DATE IS ON ALL YOUR SOIL HEALTH CARDS BEFORE YOU FILE THEM

10. MAKE A NOTE IN YOUR DIARY TO REPEAT THE TESTS AFTER 6 OR 12 MONTHS

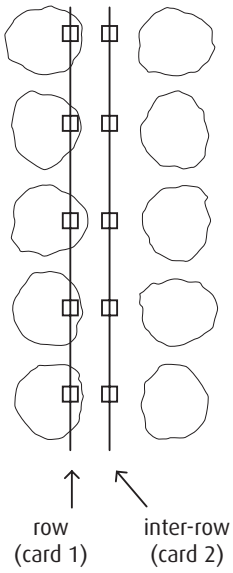
3. TEST PREPARATIONS

EQUIPMENT

- home-made wire quadrat (see Sheet 4)
- home-made penetrometer (see Sheet 4)
- home-made infiltrometer ring (see Sheet 4)
- clipboard and pencil
- one soil health card result sheet for each set of tests planned
- spade
- heavy duty plastic sheet, 1m x 1m (approx.)
- soil pH kit (available from rural stores and nurseries)
- 500 ml measuring cup
- container of water (allow 1 litre of water per sample point if soil is dry or 500 ml if soil is moist)
- watch with a second display or stop watch
- mallet, clippers, secateurs to assist pushing infiltrometer into soil
- 10 meter tape measure

SAMPLING PROCEDURE

Suggested layout of sample points:



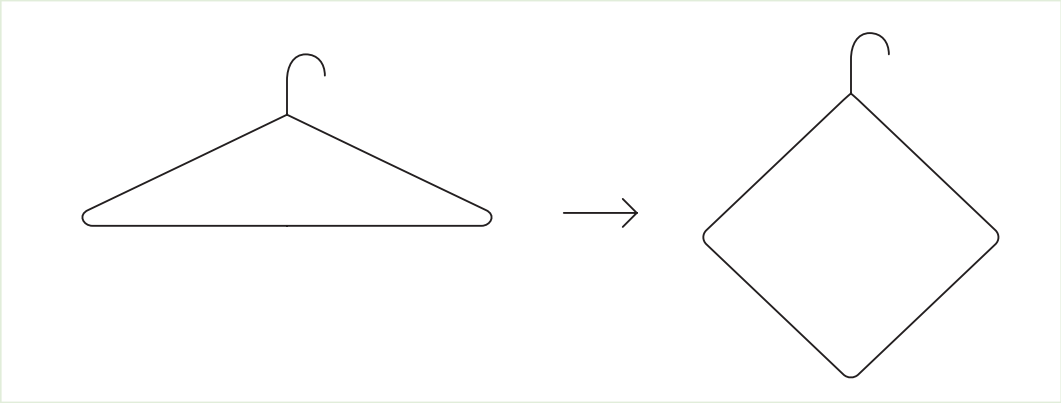
Notes

- Start from an identifiable point.
- Stay within a single soil type for each card.
- Sketch a plan of the sample points on the back of the assessment sheet and mark any soil type boundaries.

4. HOME-MADE EQUIPMENT

1. WIRE QUADRAT (TEST 1)

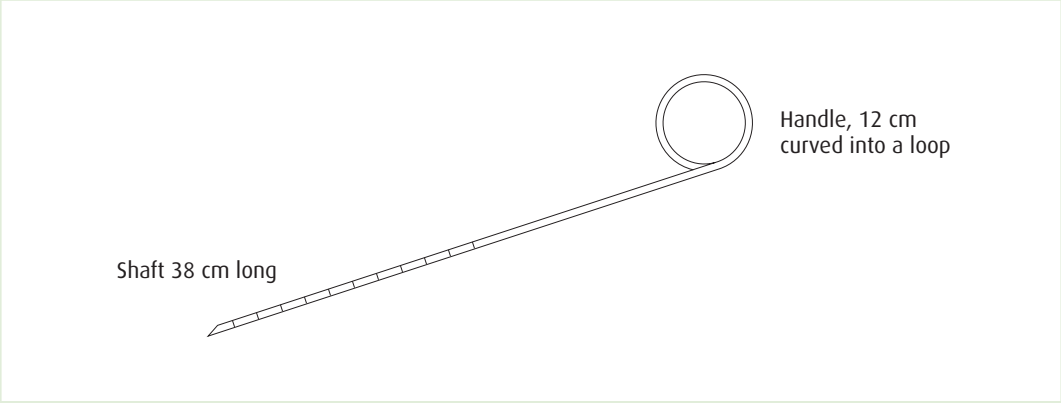
A quadrat is simply a frame that shows a known area when placed on the ground. It is used to obtain an accurate measure of anything found there. You will use it to assess the amount of plant cover and then again to record the variety of animal life in the leaf litter.



Take a wire coat hanger and open it out to form a square (each side will be approximately 24 cm in length.

2. PENETROMETER (TEST 2)

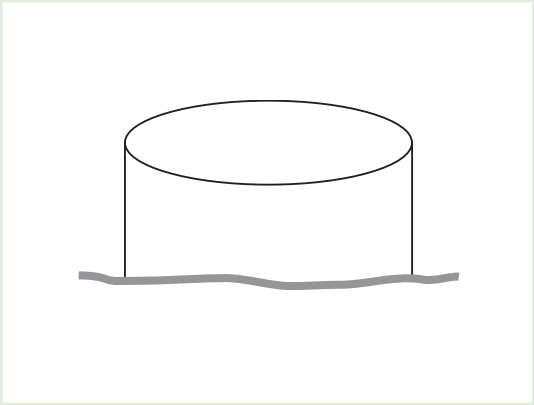
A penetrometer is a device to test the compaction of the soil. While you can buy sophisticated penetrometers for hundreds of dollars, you can make your own inexpensive version. Take a 50 cm length of 3.15mm/10 gauge high tensile wire. Use 12 cm of the length to make a handle and on the remaining 25 cm make file marks every 2.5 cm from the end.



Metal rod (50 cm long, 3.15mm diameter) with file marks every 2.5 cm starting from end of rod.

3. INFILTROMETER RING (TEST 3)

An infiltrometer measures the rate at which a fixed volume of water soaks into the soil. You will need a 150 mm diameter PVC pipe cut to 11 cm length. Bevel the bottom end to make it easier to push into the soil.



5. THE SOIL TESTS

WARNING: SOIL NATURALLY CONTAINS MANY MICROBES, SOME OF WHICH CAN CAUSE INFECTION OR DISEASE. WEAR GLOVES IF YOU HAVE INJURIES OR ABRASIONS ON YOUR HANDS.

1. DIVERSITY OF SOIL LIFE

Carefully throw the home-made wire quadrant to the ground in the area chosen to conduct the test. Examine the soil surface within the quadrant for soil animals and then carefully sift through the litter. Start turning the litter from the outer edge of the quadrant toward the center. This forces mobile soil animals to the center where they will be seen by the observer before they escape.

Note how many different varieties of soil animals you see such as ants, beetles, spiders, slaters, millipedes, mites, snails etc. It is the variety that is important, not the numbers – a column of ants counts as one variety.

2. GROUND COVER

Starting near the 'diversity of soil life' test site, stretch the tape measure 10 meters down the tree row. At each 1 meter mark, look down from directly above the tape measure and note (count) if living plant material is present; count '1' if present and '0' if absent. Always read from the same side of the tape and count only what is directly next to the 1 meter mark. Calculate the percentage of ground cover and record the your score on the results sheet.

Example: 5 counts of living ground cover out of 10 counts = 50% ground cover

Living plants contribute organic matter to the soil that will feed soil animals and microbes. Roots of living plants also help maintain good soil structure.

3. PENETROMETER

Using ONLY moderate pressure, push your homemade penetrometer into the soil. Record the depth of penetration on the results sheet. If you hit a rock or tree root, choose another spot.

The easier it is to penetrate the soil, the better the deep root development and water infiltration. Perform this test at the surface and at 20 cm depth. The 20 cm depth test is done at the bottom of the hole you will dig for test 5.

4. INFILTROMETER

If the top 7 cm of soil is dry you must perform this test twice in each location and record the time of the second test for an accurate assessment. If the soil is saturated (field capacity) you will need to wait two days for drying before conducting the infiltrometer test.

- Clear the area of residue and trim the vegetation as close to the soil as possible without disturbing the soil.
- Push the infiltrometer ring 2 cm into the soil, avoiding cracks and other holes in the ground. The ring should be nearly level for accurate testing. Use your finger to gently `firm the soil around the inside edge of the ring to prevent leakage of water here.
- Carefully pour 500 ml of water into the ring and note the time.
- Stop timing when the surface is just glistening.

A higher rate of infiltration will mean your soil will absorb rainfall more quickly, resulting in less run off and erosion.

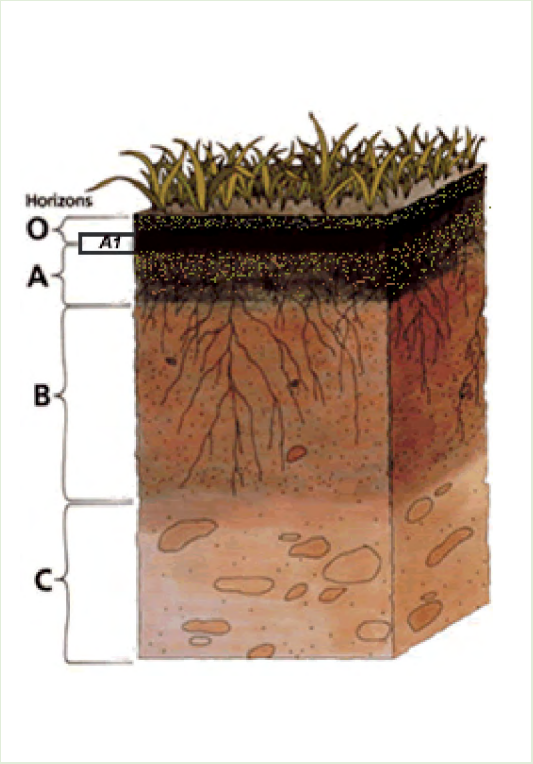
5. ROOT DEVELOPMENT

With your spade cut a 20 cm square hole to a depth of 20 cm. Lift the soil out, trying to keep it in one block, and place it on the plastic sheet. Examine the distribution of plant roots in removed soil and on the walls of the hole. Record results on the result sheet. The distribution of fine roots will show whether soil structure is restricting the plants' access to nutrients.

6. SOIL STRUCTURE

Break a small handful of soil away from near the original surface of the block you have dug up and examine the size and arrangement of the soil aggregates or 'crumbs' (discrete clumps of soil particles). Under firm finger pressure, soil should be friable, breaking into crumbs varying in size up to about 10 mm. There should also be evidence of root penetration throughout. Poor structure may be seen either as overly solid soil (hard crumbs, soil layers or clods) or as very loose soil (absence of even small crumbs, as for example in beach sand). Good structure results in easy passage of air and water, an ability to hold water and superior resistance to erosion.

7. DEPTH A-1 (ALSO KNOWN AS A-0, 01, 02) HORIZON



At the top of the soil profile is the '0' horizon. '0' stands for 'organic'.
The '0' horizon is primarily composed of organic matter in varying stages of decomposition. Fresh litter is found at the surface, while at depth all signs of vegetation structure have been destroyed. The decomposed organic matter, or humus, enriches the soil with nutrients, aids soil structure and enhances soil moisture retention.

Beneath the '0' horizon is the 'A1 (also known as the A0, 01 or 02) horizon. In this horizon organic material starts to mix with the mineral soil. Measure the depth of the dark, nutrient-rich layer of the A1 (aka A0, 01, 02) horizon. This shows as a darkened, organic colouration to this area.

Left: Soil horizon drawing adapted from USDA NRCS website.

8. EARTHWORMS

Break up the entire soil block you have dug up into crumbs, count earthworms and record on the results sheet.
Higher numbers of earthworms indicate conditions that are favourable (more organic matter, neutral pH, moist soil, low chemical residues). Mostly these are also conditions favourable for plant growth.
Earthworm burrows enhance water infiltration and soil aeration. Their digestion of soil and organic matter cycles nutrients. The presence of earthworms is a good indicator of soil health.

9. SOIL PH

Take two small samples of soil from the side of the hole, one from 5 cm and one from 20 cm depth. Test each sample for pH, following the instructions included in the kit. Acidity has a strong effect on the ability of plants to take up soil nutrients as well as upon the well-being of soil organisms.

10. TREE VIGOUR

Examining your trees at the soil test site may reveal plant health problems not identified by the completed soil tests. Examine 5 trees for poor leaf colour, canker and sparse canopy.

SOME EXTRA (OPTIONAL) TESTS

CALICO STRIP TEST FOR SOIL MICROBES

Microbes in the soil (bacteria, protozoans and fungi) play a major role in the break down of soil organic matter. Microbial activity can be estimated by measuring the rate of breakdown ('rotting') of calico. Cut unbleached and washed calico into 20 cm squares. Using a felt tip pen draw a line across the square 5 cm from one edge. Make a cut in the ground to a depth of 15 cm with the spade and, again using the spade, insert the calico so that the marked line coincides with the soil surface. Arrange the top 5 cm of calico vertically in the litter layer, if present. Use at least 5 calico strips at each test site and leave in place for three weeks. Gently retrieve and rinse in a kitchen sieve, to remove attached soil. Place over a piece of graph paper and estimate the percentage area of the calico that has completely decomposed. The more the calico has rotted away the healthier the community of soil organisms.

This test can also be done with soil in containers in a controlled atmosphere, i.e. the laundry room where moisture levels can be monitored.

EROSION

Take a 50 cm length of 100 mm x 50 mm timber and place it on the ground, across the slope, near the bottom of a long incline. After each major rainfall event check the wood for build up of soil on the upper side.

Also see Soil Erosion Solutions fact sheet; Monitoring soil erosion
http://www.northern.cma.nsw.gov.au/pdf/monitoringerosion.pdf

AGGREGATE STABILITY

Equipment – a wide mouthed jar with a lid, marked to show 125 ml level.

Select three or four pea-sized soil aggregates from about 5 cm depth, avoiding small stones. Drop the aggregates into 125 ml water in the small wide mouthed jar and allow to stand for one minute. Observe if the aggregates break apart or stay intact. If they are intact after one minute, gently swirl the bottle several times and observe again. If they are still intact, swirl the bottle vigorously and check again. The aggregates of a healthy soil are normally more stable than those of a less healthy one. Poor aggregate stability is associated with greater susceptibility to erosion. Repeat the test with a sample from a depth of 20 cm.

BIOTURBATION

Bioturbation is the mixing of surface organic matter into the soil profile by organisms. On the side of the hole dug at Test 5, observe the distribution of the darker soil colouration that is due to organic matter in the profile. Note the depth to which you can detect this darker soil and record on the back of your results sheet.

Soil health card results sheet

Numbers resulting from the different tests are not intended to be combined to give an overall value of soil health.

Date: Location: (draw a sketch map overleaf)

Soil Type: Productivity: Days since 20mm rain: Soil moisture: dry / moist

TEST ↓ RESULT →		POOR 1 ····· 2 ····· 3	FAIR 4 ····· 5 ····· 6	GOOD 7 ····· 8 ····· 9	Test Scores (1–9) 5 test sites 1	2	3	4	5	Av/Comments
1. Diversity of macrolife		Fewer than 2 types of animals	2 to 5 types of animals	More than 5 types of animals						
2. Ground cover (ground plants or mulch)		Less than 50% ground cover	50% – 75% ground cover	More than 75% ground cover						
3. Penetrometer	**· Surface**	Penetrates to less than 5 cm	Penetrates more than 5 but less than 20 cm	Penetrates to 20 cm or more.						
	· 20 cm depth									
4. Infiltration	**· Surface**	More than 3 minutes	1 to 3 minutes	Less than 1 minute						
	· 20 cm depth									
5. Root development		Few fine roots only to 5 cm	Some fine roots to 10 cm	Many fine roots to 20 cm						
6. Structure	**· Surface**	Mostly clods or surface crust, few crumbs	Some clods but many 10 mm crumbs	Friable, readily breaks into 10 mm crumbs						
	· 20 cm depth									
7. Depth 'A-1' Horizon		0 to 1.9cm	2 cm to 4.9 cm	5 or over						
8. Earthworms		0 to 1	2 to 3	4 or more						
9. Soil pH	**· 5 cm depth**	pH 5.5 or lower	pH 5.5 to 6	pH 6.1 or higher						
	· 20 cm depth	pH 5 or lower	pH 5.1 to 5.5	pH 5.6 or higher						
10. Tree Vigour: Out of 5 trees how many have sparse canopy, poor colour, canker?		2 – 5 trees	1 tree	0 trees						

***DOWNLOAD THIS PDF TO YOUR DESKTOP FIRST** to use this interactive pdf – you can fill in the test results directly on your computer and file for your records.*

Download the Soil Health Card: www.soilcare.org/soil-health-card.html

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Site plan

(Showing a permanent reference point (add GPS), 5 sample points, soil type changes etc)

Test comments

1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

The Soil Health Card can be downloaded from the following website:

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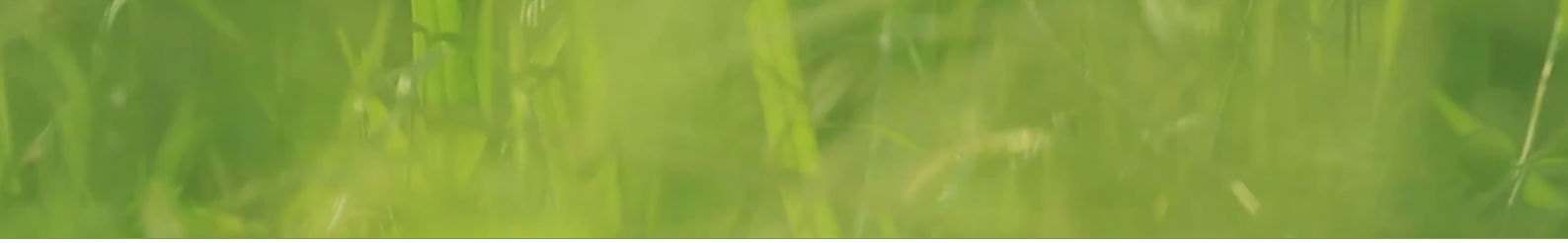
www.soilcare.org/soil-health-card.html

Low test scores: some possible causes

Test Result	Situation indicated	Possible causes
1) Low variety of soil life	• lack of habitat or food for fauna • poor soil structure • presence of harmful chemicals	• sparse litter, low soil organic matter (OM), lack of soil spaces and channels • frequency or intensity of machinery has been excessive • mortality from recent use of insecticides or regular use of cumulative chemical(s) such as copper
2) Low ground cover	• ground plants absent or • growth is poor	• unsuitable plant type(s), soil compaction, erosion, shading, herbicide use • over grazing
3) Low probe penetrability	• soil is generally hard • hard at the surface only • hard layer at greater depth	• compacted by over-working, low soil organic matter • compacted by traffic, especially if soil is wet at the time • compacted by heavy vehicles or 'hard pan' formed by soil inverting cultivators
4) Slow water infiltration	• high proportion of clay particles • lack of spaces, channels or • burrows in soil	• naturally high clay content of soil type, possible loss of topsoil • soil compaction, poor soil structure, lack of earthworms, surface crusting
5) Poor root development	• hard soil lacking spaces • poor plant nutrition • root disease or attack	• loss of topsoil, poor soil structure, soil compaction • soil pH not suitable for crop, lack of major or minor nutrients • presence of soil-borne pathogen, root-feeding nematodes or root-feeding insects
6) Poor soil structure	• powdery soil, few crumbs • excessive clods	• lack of soil-binding substances and processes, low soil organic matter (sparse ground cover), few worms • topsoil loss, soil compaction, low soil organic matter
7) Lack of depth 'A-1' horizon	• low organic matter • low population soil organisms	• loss of topsoil, sparse ground cover (see 1) , copper toxicity • low variety of soil fauna (see 2), few earthworms (see 8)
8) Low earthworm count	• pH unfavourable • poor food supply • lack of soil spaces • predators or parasites present • presence of harmful chemical	• soil pH naturally low, pH reduced by use of acidifying fertilisers • sparse litter and/or ground cover (and roots), low organic content, low populations of fungi and bacteria • loss of topsoil, soil compaction, poor structure • predators (eg flatworms) and parasites (eg parasitic fly) may occur in 'plague' numbers • mortality from recent use of insecticides or regular use of cumulative chemical(s) such as copper
9) Low pH	• high level of acidity	• **5 cm:** calcium levels low, excess of nitrogen from inorganic fertilisers, poor drainage, low OM • **20 cm:** as above; if pH is less than 4 consider acid sulfate soil (grey clay/ sometimes yellow veins)
10) Poor tree vigour	• unthrifty trees	• soil problem as indicated in tests 1–9, one or more essential nutrients deficient or unavailable (confirm via soil or leaf analysis), low organic matter, disease/Phytophthora



Disclaimers: The information contained in this publication is based on knowledge and understanding at the time of writing (2025). However, because of advances in knowledge, users are reminded of the need to ensure that information on which they rely is up to date, and to check the currency of the information with the appropriate officer of NSW Agriculture or the users independent adviser.

The Northern Rivers Soil Health Card for macadamia farmers was developed in a series of workshops with local farmers, facilitated by NSW North Coast TAFE Wollongbar staff, NSW DPI staff, Richmond Landcare staff and SoilCare Inc members. SoilCare Inc thanks all the people who, in their concern for soil health, volunteered their time and expertise to ensure the production of a card that would be useful and relevant for farmers.

Macadamia Industry Participants:

- Denis Byrne, farmer
- Ken Dorey, farmer
- Mark Dorey, farmer
- Bob Evans, Australian Macadamia Society/farmer
- Peter Fleming, farmer
- Neil Jung, farmer
- Phill McCarthy,
- Jim Patch
- Neil Woods, farmer
- Pam Woods, farmer

Facilitators:

- Dave Forrest, TAFE Wollongbar
- Alan Coates, TAFE Wollongbar
- Abigail Jenkins, NSW Dept. Primary Industries
- Jackie Luethi, Richmond Landcare Inc
- Bonnie Walker, SoilCare Inc

SoilCare Inc thanks the farmers and sponsors whose concern for soil health provided this opportunity.

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